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Display Routine for Manned LM Flights

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References: (a) MSC FA40, "Latest in Luminary for Apollo 14," dated 24 July 1970, received 29 July 1970.

(b) Revision 31 of AGC Program Zerlina, dated 16 July 1970, received 24 July 1970.

Reference (a) indicates that MSC plans to incorporate the landing analog display routine of reference (b) into the LM program for the manned Apollo 14 flight. A review of the coding in reference (b) reveals that the following penalties will have to be paid for this MSC decision (when evaluated against the performance of the Luminary 173 program):

1) Luminary 173 (and the Apollo 13 program) had anomaly L-1B-04 fixed, while reference (b) does not. Hence if RR error counters should be disabled, then no automatic enabling of them is done (a check of bit 2 of channel 12 is needed). Although the anomaly report is not available, reference to Luminary memo #121 indicates that one way for error counter enable to be reset is "when the RR is cycled on and off."

2) Luminary 173 computed information for R1 of N60 (forward velocity) regardless of the position of the switch on the spacecraft panel controlling display of data on the meters. This change, "authorized" by ACB L-11 (it impacted Section 2 and Section 4 GSOPs), is not in reference (b). Consequently, the warning note on page 1-7 and 1-49 of the Apollo 14 Flight Crew G&N Dictionary (15 June 1970) that proper R1 data "requires MODE SEL - PGNS" for N60 must be retained, whereas its deletion was possible if Luminary 173 had been used.

3) Luminary 173 allowed the maximum display on the crosspointers (at least as fed to the error counters) be about 200 fps, in accordance with the information on the required range given on page 5.3-118 of the Section 5 Rev. 8 Approved by NASA GSOP. Reference (b), however, contains a constant which seems to limit the maximum display to only about half this number (the quantity MAXVEL, line 0140 on page 43, has a value of 00233_8 which seems to be about $99.32 \times 0.3048 \times 0.01 \times 2^{-5}$, where first term is fps, 2nd converts to meters, 3rd to centi-seconds, and fourth is scale factor). The program comments indicate a scale factor of "B6", which has not been successfully supported by the computations on pages 884-5, which seem to make use of a quantity scaled B5 instead.

4) Although Luminary 173 made use of single precision computations, it provided them with a consistent sign. Page 884 of the listing, however, computes forward velocity information as:

$$\text{FORVTEMP} = \text{M32 VHZ}_{dp} - \text{M22 VHY}_{sp} + \text{M22 VHY+1}_{sp}$$

It appears that the last term has the wrong sign, thus raising the question, in view of presumably successful tests, of whether it needs to be included at all. Its omission would save a small amount of execution time.

5) An apparently influencing factor in reference (a) was that the program "begin displaying analog data at TIG - 30 seconds" (item (d) on page 1). Since Average-G state vector initialization is for TIG - 29.9 seconds, however, the first display (setting of a flagbit) would not be expected to be initiated until some time after TIG - 27.9 seconds, not "TIG - 30" as specified by MSC.

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Given on the following pages is some information on the equations in reference (b), in the event this material may have some relationship to what is put in the manned LM Apollo 14 program.

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Comments on Compatibility of Luminary 163 Pro[illegible]
with MSC-approved PCRs 287 and 1038

References: (a) Revision 163 of AGC Program Luminary, dated 29 April 1970, received 18 May 1970.

(b) PCR 287, "Removal of 526 Alarm in P22 and P20," dated 25 September 1969.

(c) PCR 1038, "Keep 526 Alarm in P20 (PCR 287)," dated 27 April 1970.

A review of reference (a) has revealed several incompatibilities between the performance of the program and that authorized by MSC via references (b) and (c). These include:

1. Addition of a lockout on P25 (Preferred Tracking Attitude Program) for ranges in excess of about 566 nmi (see anomaly LNY 48). If such a range is encountered, a non-display 526 alarm may be generated (depending on the "left-over" status of a flagword bit), and manual selection of N54 could reveal present range. When range gets below 400 nmi, an attempt will be made to start through the P20 program (creating, if radar not in Auto, a priority 514_8 alarm, for example). No mention of P25 was located in references (b) or (c).

2. Addition of a check before generation of the V16 N54 display in P22 that will cause "GOTOPOOH" to be entered (via V56 logic) if range rate is determined to be positive on first pass through the computations. No mention of such a check was located in references (b) or (c).

3. Incorporation of a "memory" bit (bit 10 of FLAGWRD0), also used by R26, that is not set for entrances to the logic that can occur outside of initial selection of P20/P22. In particular, it is not set for a PRO response (which might be done quite late compared to first lock-on) to the N80 display in R24, nor is it set for entrances to the logic from the "LPS20.1" routine, which is used by R61 and R65 (among others). As a result, depending on the status of the "memory bit" an indication to the crew of what is happening may or may not be provided.

Item 1 above is due to the deletion of a check on RNDVZFLG in "LPS20.1" that formerly avoided rescaling from B29 to B20 if the bit was zero. As mentioned, "LPS20.1" is used by R61 and R65 (and P25 uses R65, after first setting RNDVZFLG = 0). Items 2 and 3 should be self-evident from examination of the coding.